Attorney Docket No. 3600.100

#8

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Reissue Application of) Examiner: C. Verdier

DAVID A. SPEAR ET AL.) Group Art Unit: 3745

Appln. No.: 09/343,736)

Filed: June 30, 1999)

For: SWEPT TURBOMACHINERY BLADE)

Commissioner for Patents
Washington, D.C. 20231

SECOND DECLARATION OF HARRIS D. WEINGOLD
UNDER 37 C.F.R. § 1.132

Sir:

I, Harris D. Weingold, do hereby declare as follows:

1. I am the same Harris D. Weingold who executed the Declaration of Harris D. Weingold Under 37 C.F.R. § 1.132 dated December 27, 1999, in the above-identified application ("the First Weingold Declaration").

2. In connection with this declaration I have studied the Office Action of October 6, 2000 ("the Office Action"), in the above-identified application, and U.S. Patents No. 2,660,410 to Hull, Jr. ("Hull"), No. 2,915,238 to Szydlowski ("Szydlowski"), and No. 4,714,407 to Cox et al. ("Cox"), which are specifically discussed in the Office Action. I remain familiar with the specification and claims 1-41 filed as the present application to reissue U.S. Patent 5,642,985 to David A.

Spear et al. and the references listed on Exhibit C to the First Weingold Declaration. I am familiar with independent claims 10, 18, 20, 30 and 36 in the present application, as shown in the attached Appendix hereto. The underlining and bracketing indicate additions and deletions to the language of the corresponding as-filed claims, and I am informed that the amended claims shown in the Appendix will be submitted in a response to the Office Action.

A. <u>INTRODUCTION</u>

3. When considering the claims shown in the attached Appendix, it is important to keep in mind that the term "sweep," when used to define a property of the leading edge of a turbomachinery blade, has a very precise definition to one skilled in this art. Specifically, "sweep angle" at a particular radial location on a blade's leading edge refers to the angle formed at that location by (i) a line tangent to the blade leading edge in a plane containing the relative velocity vector of the working medium gas and (ii) a plane normal to the relative velocity vector. See also the First Weingold Declaration at paragraph 18.

4. The manner in which the present application, including the attached claims, use this term is illustrated in Figure 4 of the present application, reproduced below:

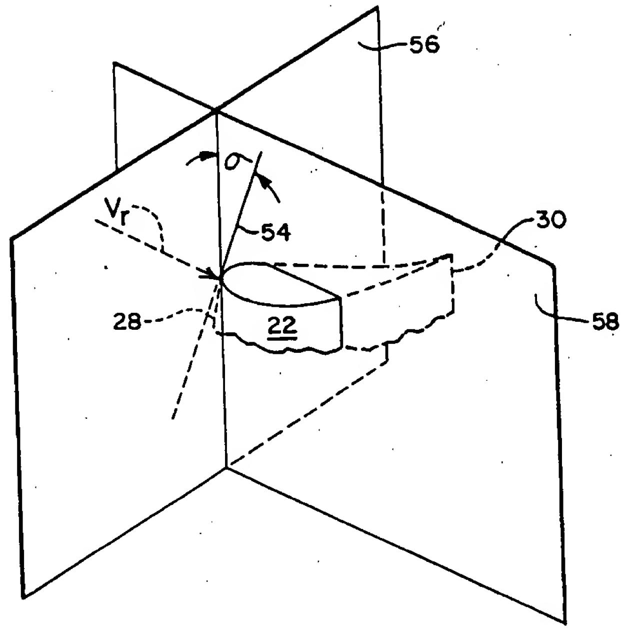


FIG. 4

5. The sweep angle σ of the leading edge of the blade 22 is the angle between the line 54 and the plane 56. The line 54 is tangent to the blade leading edge 28 and is in a plane 58 containing the relative velocity vector V_r. The plane 56 is normal to the relative velocity vector V_r, so the sweep angle is measured in the plane 58. See the present application at page 3, lines 20-29.

6. In other words, the sweep angle of a blade leading edge is defined in terms of the velocity vector of the airflow approaching the blade. Therefore, it is necessary to know not only the blade geometry, but also the characteristics of the flow environment (either by actual measurement or by computer simulation) in which the blade is operating, to determine the sweep angle profile of the blade's leading edge. Without knowing

the flow conditions and the exact geometry of the blade, it is impossible to determine the leading edge sweep angle.

B. <u>THE HULL PATENT</u>

7. Hull purports to describe a turbine bucket with increased structural stability. Hull's turbine bucket has three radial regions 2a, 2b and 2c as shown in the side view depicted by Figure 2. The inner region 2a is crescent-shaped in cross section and constitutes an impulse-type blade. It has a substantial thickness, which, along with its cross-sectional configuration, is said to make it resistant to vibration in a tangential direction. Hull at column 3, lines 6-18. The outer region 2c has a thin airfoil-shaped cross section, with a smaller cross-sectional area than the inner region 2a. Hull at column 3, lines 35-40. The middle region 2b transitions between the inner region 2a and the outer region 2c. Hull at column 3, lines 51-55. Hull says that this particular configuration "provides a blade which has been found to have unusual resistance to vibration in a tangential direction relative to the bucket wheel to which it is secured." Hull at column 4, lines 55-58. This, Hull says, is a consequence of the tangential moment of inertia profile that results from the described blade configuration. Hull at column 4, lines 20-36; Figure 5.

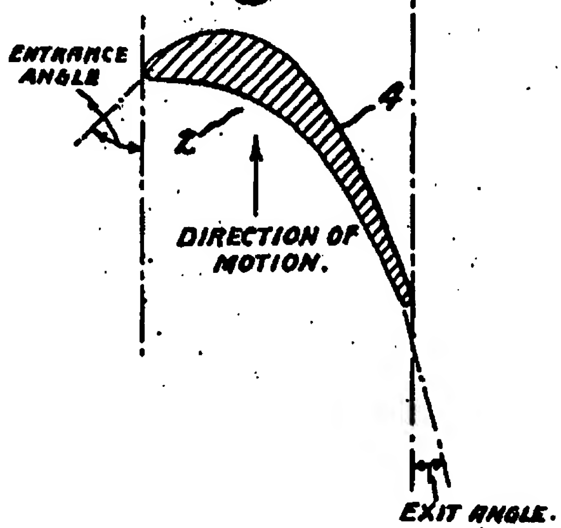
8. Hull contains no disclosure that one of ordinary skill in the art would have interpreted as suggesting that the

leading edge of the disclosed blade has any particular sweep angle profile.

9. One of ordinary skill in the art would not have found the depiction of a turbine bucket in Hull's figures to impart any information regarding the sweep angle profile of the bucket's leading edge. That is, those skilled in the art, knowing that sweep angle cannot be determined without information about the blade's exact configuration <u>and</u> the characteristics of its flow environment (either by actual measurement or by computer simulation), would immediately recognize that Hull's simple pictorial representations are insufficient alone to impart information concerning the leading edge sweep angle profile of Hull's turbine bucket. This is in part because sweep angle depends on a particular three dimensional relationship of the velocity vector to the blade leading edge, as discussed above in paragraphs 3-6. There is no information whatever in Hull concerning leading edge sweep angle. Nor is there anything about the turbine bucket depicted in Hull's figures or the flow conditions discussed in Hull that would inherently and necessarily produce a particular leading edge sweep angle profile. In other words, Hull contains insufficient information, either about the depicted turbine bucket's geometry or the flow conditions, for one of ordinary skill in the art to have been able to determine the leading edge sweep angle profile of Hull's turbine bucket.

10. The only discussion in Hull relating to angles formed between the disclosed turbine bucket and the flow over it relates to the entrance and exit flow angles of the three regions of the blade. Hull at column 3, lines 22-24, lines 47-50 and lines 63-65. The nature of these angles can be best appreciated by considering Figure 4 of Hull, reproduced below:

Fig.4.



11. This depiction shows that the entrance and exit angles depend solely on the angles at which the flow approaches the leading edge and leaves the trailing edge, respectively, in a plane taken at a radial section of the blade. It will be immediately apparent from a comparison of Hull's Figure 4 and the applicants' Figure 4, reproduced in paragraph 4 above, that the entrance and exit angles of Hull's bucket 2 are not the same as the sweep angle σ of the present invention.

12. As an expert in the field of axial flow turbomachinery (see the First Weingold Declaration at paragraphs 2-4), I can state with certainty that there is insufficient information in Hull to determine the amount of sweep in the turbine bucket described in Hull at any particular radial location. The appearance of the turbine bucket in side elevation, even combined with knowledge of the flow entrance and exit angles (as defined by Hull), provides no insight into the values of the sweep angle of the turbine bucket's leading edge.

13. Turning now to the claims shown in the attached Appendix, claim 10's blade has a leading edge with an intermediate region and a tip region beginning at an outward boundary of the intermediate region. The sweep angle of the intermediate region does not decrease from an inward boundary of the intermediate region to the outward boundary thereof, and the sweep angle throughout the tip region is less than the sweep angle at the intermediate region's outward boundary. Claim 20 recites turbomachinery with a plurality of blades each of which has those features. Since Hull contains no teaching concerning sweep angle, one of ordinary skill in the art would not have read Hull to have suggested blades with leading edge profiles like those recited in the applicants' claims 10 and 20.

14. Claim 18 recites a blade that has a leading edge with a rear swept intermediate region and a tip region beginning

at an outward boundary of the intermediate region. The sweep angle of the intermediate region does not decrease from an inward boundary of the intermediate region to the outward boundary thereof, and the tip region is translated forward relative to a leading edge with the same sweep angle as the outward boundary of the intermediate region. Claim 30 recites a blade with a rear swept middle region ending at a tip region. The sweep angle of the middle region does not decrease throughout the middle region, and the tip region is translated forward relative to a leading edge with the same sweep angle as the end of the middle region. Since Hull contains no teaching concerning sweep angle, one of ordinary skill in the art would not have read Hull to have suggested blades with the leading edge profiles recited in claims 18 and 30.

15. The Office Action points to Figure 2 of Hull, and as I understand it, says that this side view suggests a blade having a leading edge with a rear swept intermediate region and a tip region with a sweep angle that either is less than the sweep angle at the outward boundary of the intermediate region or is translated forward from the end of the intermediate region. In other words, the Office Action indicates that Figure 2 suggests a blade that meets the above mentioned language of claims 10, 18, 20 and 30.

16. Actually, one skilled in the art would not have been able to tell anything about the sweep angle profile of the

turbine bucket's leading edge from Figure 2 in Hull. In the first place, even though it might seem at first glance that a direct comparison can be made between Hull's Figure 2 and the blade side view in the applicants' Figure 2, in reality that is not the case. For one thing, the applicants' specification notes that the sweep angles shown in Figure 2 are actually "projections of the actual sweep angle onto the plane of the drawing." <u>See</u> the present application at page 3, lines 26-29. They do <u>not</u> depict sweep angle. For another, Hull's entrance and exit angles only determine the relation of the velocity vector relative to the leading edge in a single plane. To be able to determine sweep angle, the radial component of the relative velocity vector must also be known, as well as the angle formed by a line tangent to the leading edge in a plane containing the velocity vector and a plane normal to the relative velocity vector. Hull simply does not contain enough information to make these geometric determinations.

17. In addition, the blade shown in Hull is a turbine bucket, while the applicants' Figure 2 depicts a fan blade. While not all of the applicants' claims are limited to fan blades, those skilled in the art understand that a side elevation of a turbine bucket does not necessarily impart information about the sweep angle of the bucket's leading edge in the same manner as such a view of a fan blade. That is, the velocity vector approaching a turbine bucket reflects a completely different flow

environment because the working medium is driving the turbine bucket to extract energy from the working medium. This contrasts with the situation presented by a fan or compressor blade, which is imparting energy to the working medium. Accordingly, a direct comparison of Hull's figures and the applicants' figures is not relevant to the question of whether the turbine bucket in Hull's figures and the fan blade in the applicants' figures have similar leading edge sweep angle profiles. Moreover, the fact is that one of ordinary skill in the art would not necessarily understand the applicants' Figure 2 to disclose a particular leading edge sweep angle profile just from this depiction of a side elevation, without having additional information, such as parameters defining the blade's geometry and flow environment or a detailed discussion regarding the blade's leading edge profile such as is included in the applicants' specification.

18. Finally, it is not clear to me what portion of Hull's turbine bucket the Office Action considers its intermediate (middle) and tip portions. The Office Action discusses the applicants' independent claims 10, 18, 20 and 30 in connection with Hull. All of those claims recite blades with an intermediate portion having a leading edge with a sweep angle that does not decrease from beginning to end. If Hull's region 2b is considered to correspond to the applicant's intermediate region, then even if the side view in Hull's Figure 2 were considered to depict sweep angle, Hulls' turbine bucket clearly

would not have suggested the applicants' claimed structure. On the other hand, the Office Action might be read as saying that Hull's Figure 2 suggests an intermediate region that ends somewhere below where the lead line for reference numeral 2 meets the bucket's leading edge. However, even then Hull includes no suggestion of a sweep angle of the turbine bucket shown in Figure 2, for all of the reasons discussed above.

19. Accordingly, it is my opinion that one of ordinary skill in the art would not have found the leading edge sweep angle profile recited in claims 10, 18, 20 and 30 to have been in any way suggested by anything in Hull.

C. THE COX PATENT

20. Cox relates to turbomachinery blades, particularly for a turbine, having a trailing edge configuration that results in the streamlines of the gas flow through the turbine having a desired geometric relation to the trailing edge. Cox at column 2, line 25, to column 3, line 25. The blade leading edge is not of concern in connection with the blade configuration described by Cox. Cox at column 7, lines 26-31. Moreover, Cox does not include any discussion regarding leading edge sweep angle or anything that would inherently and necessarily have taught one of ordinary skill in the art a particular leading edge sweep angle profile.

21. That is, Cox, like Hull, contains insufficient information, either about the blade geometry or the flow

conditions, for one of ordinary skill in the art to have been able to determine the leading edge sweep angle profile for Cox's blade. In other words, Cox contains no disclosure that one of ordinary skill in the art would have interpreted as suggesting a particular sweep angle profile for the disclosed blade's leading edge.

22. The Office Action refers to Figure 10B of Cox as showing a particular leading edge profile. As has been discussed above, a blade's sweep angle cannot be determined simply by considering the appearance of the blade's leading edge when viewed from a particular perspective. Cox's Figure 10B is actually a <u>rear elevation</u> of the blade, as stated in Cox at column 3, lines 45-46.

23. A better way of gaining insight into the relationship between Cox's blade and the applicants' invention is to consider the following orthogonal views from Cox:

<u>Side Elevation</u>

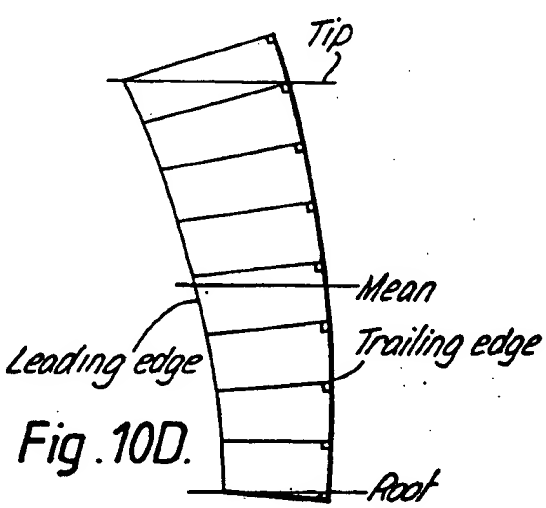


Fig.10D.

<u>Rear Elevation</u>

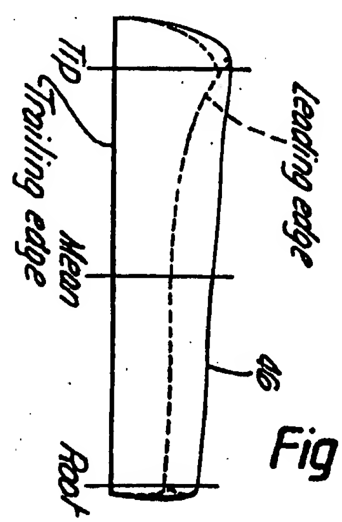


Fig.10B.

24. Thus, when viewed from the side, the perspective most likely to be indicative of the sweep angle of the leading edge, the leading edge profile of Cox's blade cannot even be said to look like that of the applicants' claimed blades. This can also be appreciated by comparing Cox's Figure 10D with the applicants' Figures 2 and 6, which show side elevations of embodiments of the applicants' blades. Page 2, lines 17-22 and 31-34. Accordingly, it cannot even be said about Cox that it suggests the applicants' invention because of a superficial similarity between side views of the applicants' and Cox's blades.

25. In fact, there is actually nothing in Cox that one of ordinary skill in the art would have found informative regarding the sweep angle of the described blade's leading edge, and Cox contains no disclosure that one of ordinary skill in the art would have interpreted as suggesting that the leading edge of the disclosed blade has any particular leading edge sweep angle profile. This is because sweep angle depends on the three dimensional relationship of the velocity vector to the blade leading edge, as discussed in paragraphs 3-6 above. Nor is there anything about the blade or flow conditions discussed in Cox that would inherently and necessarily produce a particular leading edge sweep angle configuration. In other words, Cox contains insufficient information, either about the blade geometry or the

flow conditions, for one of ordinary skill in the art to have been able to determine the leading edge sweep angle profile for Cox's blade. It is also relevant that Cox specifically says that the leading edge of the blades shown in FIGS. 10, 11 and 12 "does [*sic*] not embody this invention." Cox, at column 7, lines 26-27. That makes it even less likely that one skilled in the art would have taken Cox to teach anything about blade leading edge sweep angle profiles.

26. Turning now to the claims shown in the attached Appendix, claim 10 recites a blade that has a leading edge with an intermediate region and a tip region beginning at an outward boundary of the intermediate region. The sweep angle of the intermediate region does not decrease from an inward boundary of the intermediate region to the outward boundary thereof, and the sweep angle throughout the tip region is less than the sweep angle at the intermediate region's outward boundary. Claim 20 recites turbomachinery with a plurality of blades each of which has those features. Since Cox contains no teaching concerning sweep angle, one of ordinary skill in the art would not have read Cox to have suggested a blade with the leading edge profile recited in the applicants' claims 10 and 20.

27. Claim 36 recites a blade with a forward swept middle region ending at a tip region. The sweep angle of the middle region does not decrease throughout the middle region, and

the tip region is translated rearward relative to a leading edge with the same sweep angle as the end of the middle region. Since Cox contains no teaching concerning sweep angle, one of ordinary skill in the art would not have read Cox to have suggested a blade with the leading edge profile recited in claim 36.

28. The Office Action points to Figure 10B of Cox, and as I understand it, says that Figure 10B suggests a blade having a leading edge with a forward swept intermediate region and a tip region with a sweep angle that either is less than the sweep angle at the outward boundary of the intermediate region or is translated rearward from the end of the intermediate region. In other words, the Office Action indicates that Figure 10B suggests a blade that meets the above mentioned language of claims 10, 20 and 36.

29. In reality, one skilled in the art would not have been able to tell anything about the sweep angle of the Cox blade's leading edge from Cox's figures. In the first place, even a direct comparison of the closest depiction in Cox to the applicants' blade (that is, Figure 10D of Cox) clearly does not suggest the applicants' claimed invention. And even though it might seem at first glance that a direct comparison can be made between Cox's Figure 10D and the blade side view in the applicants' Figures 2 and 6, in reality that is not the case. It should be noted that the applicants' specification says that the

sweep angles shown in Figures 2 and 6 are actually "projections of the actual sweep angle onto the plane of the drawing." See the present application at page 3, lines 26-29. They do not depict sweep angle.

30. In addition, the blade shown in Cox is primarily for use as turbine rotor or stator blade, while the applicants' Figure 2 depicts a fan blade. While not all of the applicants' claims are limited to fan blades, those skilled in the art understand that a side elevation of a turbine blade does not necessarily impart information about the sweep angle of the blade's leading edge in the same manner as a side view of a fan blade. Accordingly, a direct comparison of Cox's figures and the applicants' figures is not particularly informative. See paragraph 17 above. Moreover, one of ordinary skill in the art would not understand even the applicants' Figures 2 and 6 to disclose a particular leading edge sweep angle profile without the labeling that is included on those depictions and the accompanying discussion in the applicants' specification.

31. Accordingly, it is my opinion that one of ordinary skill in the art would not have found the leading edge sweep angle profile recited in claims 10, 20 and 36 to have been in any way suggested by anything in Cox.

D. THE SZYDLOWSKI PATENT

32. Szydlowski, like Hull and Cox, has no teaching regarding sweep angle. Moreover, there is nothing inherent about

the compressor or flow conditions disclosed in Szydlowski that would have led one skilled in the art to conclude that the compressor blades described therein have any particular sweep angle.

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that the statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under § 1001 of Title XVIII of United States Code, and that such willful false statements made jeopardize the validity of this application or any patent issued thereon.

Date: Apr. 10, 2001

Harris D. Weingold

Application No. 09/343,736
David A. Spear et al.
Filed: June 30, 1999

APPENDIX TO SECOND DECLARATION OF HARRIS D. WEINGOLD

10. A blade for a gas turbine engine fan comprising a plurality of blades mounted for rotation within a case circumscribing the blades and forming an outer boundary for a working medium gas flowing through passages formed by neighboring blades, wherein:

the blade has a configuration enabling the fan to rotate at speeds providing supersonic flow velocities in at least a portion of each passage;

the blade has a leading edge with an intermediate region and a tip region beginning at an outward boundary of the intermediate region and extending to a tip end of the blade, the intermediate region having a sweep angle that does not decrease from an inward boundary of the intermediate region [the beginning] to the outward boundary of the intermediate region; and

throughout the tip region the sweep angle is less than the sweep angle at the outward boundary of the intermediate region.

18. A blade for a gas turbine engine fan comprising a plurality of blades mounted for rotation within a case circumscribing the blades and forming an outer boundary for a working medium gas flowing through passages formed by neighboring blades, wherein:

the blade has a configuration enabling the fan to rotate at speeds providing supersonic flow velocities in at least a portion of each passage;

the blade has a leading edge with an intermediate region and a tip region beginning at an outward boundary of the intermediate region and extending to a tip end of the blade, the intermediate region being swept rearward at a sweep angle that does not decrease from an inward boundary of the intermediate region [the beginning] to the outward boundary of the intermediate region; and

the tip region is translated forward relative to a leading edge with the same sweep angle as [from] the outward boundary of the rearwardly swept intermediate region.

20. Turbomachinery for a gas turbine engine, comprising a plurality of blades mounted for rotation within a case circumscribing the blades and forming an outer boundary for a working medium gas flowing through passages formed by neighboring blades, wherein:

each blade has a configuration enabling the turbomachinery to rotate at speeds providing supersonic working medium gas velocities at least in the vicinity of the passages proximate to the case;

each blade has a leading edge with a swept intermediate region and a swept tip region beginning at an outward boundary of the intermediate region and extending to a tip end of the blade, the intermediate region of each blade having a sweep angle that does not decrease from <u>an inward boundary of the intermediate region</u> [the beginning] to the outward boundary of the intermediate region; and

throughout the tip region the sweep angle of each blade is less than the sweep angle at the outward boundary of the intermediate region.

30. A blade for a gas turbine engine rotatable within a case at speeds providing supersonic flow over at least a portion of the blade, wherein the blade has a leading edge with [has] a rear swept middle region having a sweep angle that does not decrease throughout the middle region and ending at a tip region that is translated forward relative to a leading edge with the same sweep angle as [from] the end of the middle region.

36. A blade for a gas turbine engine rotatable within a case at speeds providing supersonic flow over at least a portion of the blade, wherein the blade has a leading edge with [has] a forward swept middle region having a sweep angle that does not decrease throughout the middle region and ending at a tip region that is translated rearward relative to a leading edge with the same sweep angle as [from] the end of the middle region.